

Claims

What is claimed is:

- 1 **1.** A magnetically coupled RF antenna range extender structured
2 for extending an operating range between an RF antenna and an
3 electronic device, the antenna range extender comprising:
 - 4 a) a passive series tuned resonate circuit including:
 - 5 i) a coil formed of at least one turn of an electrical
6 conductor, the coil having a first end and a second end; and
7 ii) a capacitor arranged with a first terminal and a
8 second terminal, with the first end of the coil electrically
9 connected to the first terminal and the second end of the coil
10 electrically connected to the second terminal, thereby forming
11 a tuned resonate circuit;
 - 12 b) the antenna range extender located proximate to one of
13 the RF antenna and the electronic device, and not directly
14 connected to either, but closely positioned and oriented such
15 that a magnetic coupling is effected when an RF signal is
16 transmitted by the RF antenna, and subsequently received by the
17 electronic device via the antenna range extender and the
18 magnetic coupling;
 - 19 c) wherein the antenna range extender is employed for
20 increasing an operating range over which an exchanging of

information between the RF antenna and the electronic device can occur.

2. The antenna range extender as recited in claim 1, wherein the electronic device is an RFID device, and the antenna range extender is oriented with a center orthogonal axis of the coil substantially aligned with an axis extending between the RF antenna and the RFID device.

3. The antenna range extender as recited in claim 2, wherein the electronic device is a passive RFID tag.

4. The antenna range extender as recited in claim 2, wherein the coil is formed substantially upon a plane and provided by one of:

a) an insulated electrical wire substantially formed into a plurality of loops having an electrically open center area; and

b) a printed circuit coil formed of an electrical conductor that is provided fixed to a flattened substrate.

5. The antenna range extender as recited in claim 4, wherein the capacitor is provided by at least one of:

a) a discrete non-polarized capacitor;

b) a surface mounted non-polarized capacitor; and

5 c) an adjustable trim capacitor.

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1 6. The antenna range extender as recited in claim 5, wherein
2 the coil is structured and shaped in at least one of:

3 a) a substantially rectangular shape having a width and
4 height each in the range of 1 to 10 centimeters;

5 b) an oval-shape having a width and height each in the range
6 of 1 to 10 centimeters; and

7 c) a circular shape, having a diameter in the range of 1 to
8 10 centimeters.

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1 7. The antenna range extender as recited in claim 1, wherein:

2 a) the coil is provided having an inductance in the range of
3 3 to 7 microhenries, and structured with an open center area of
4 from 1 to 10 square centimeters; and

5 b) the capacitor is provided having a capacitance in the
6 range of 10 to 30 picofarads.

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1 8. The antenna range extender as recited in claim 1, wherein
2 the RF antenna is an antenna portion of a reading head of an
3 RFID interrogator, and the antenna range extender is fixed
4 proximate to the RF antenna of the reading head.

1 9. The antenna range extender as recited in claim 8, wherein
2 the antenna range extender is mounted within a hand-holdable
3 housing of the RFID interrogator.

1 10. The antenna range extender as recited in claim 1, wherein
2 the coil is formed upon a substrate of a printed circuit board,
3 and structured with at least one loop.

1 11. The antenna range extender as recited in claim 10, wherein
2 the RFID tag and the capacitor are each mounted upon the
3 substrate of the printed circuit board, with the coil located
4 proximate to the RFID tag for supporting a magnetic coupling
5 therebetween.

1 12. A magnetically coupled antenna range extender that is fixed
2 at a selected distance from at least one of an RF antenna and
3 an electronic device, and structured to extend the range at
4 which an RF signal emitted from the RF antenna can be received
5 by the electronic device located within a magnetic field of the
6 RF signal, the antenna range extender comprising:

7 a) a multi-turn coil having an open center area and formed
8 of a selected size and a selected number of turns, the coil
9 formed by at least one of:

i) an insulated wire having a first end and a second end, with each respective turn of the coil closely positioned proximate to a next turn of the coil; and

ii) a conductor fixed upon a substrate and formed of a plurality of substantially concentric coils provided via a spiral pattern fixed to the substrate, with a non-conductive substantially open center area; and

b) a capacitor having a first terminal and a second terminal, with the first terminal of the capacitor coupled to the first end of the coil and the second terminal of the capacitor coupled to the second end of the coil;

c) the coil and the capacitor thereby forming a series tuned resonate circuit having a resonate frequency substantially equivalent at least one carrier frequency employed to support an exchange of information between the RF antenna and the electronic device;

d) with the antenna range extender oriented and located proximate to at least one of:

i) an axis establishable between the RF antenna and the electronic device;

ii) the RF antenna; and

iii) the electronic device;

e) wherein the antenna range extender is configured so as to increase the operating range at which information can be

exchanged between the RF antenna and the electronic device,
when a magnetic coupling results from an emitting of an RF
signal transmitted by the RF antenna and received by the
electronic device via the antenna range extender and the
magnetic coupling.

13. The antenna range extender as recited in claim 12, wherein
the antenna range extender is fixed proximate to the RF
antenna.

14. The antenna range extender as recited in claim 13, wherein
the RF antenna is a portion of an RFID interrogator and the
antenna range extender is fixed proximate to the RF antenna
within a shared housing.

15. The antenna range extender as recited in claim 14, wherein
the electronic device is a passive RFID tag.

16. The antenna range extender as recited in claim 12, wherein
the coil and capacitor are provided as:

a) the coil having an inductance in the range of 3 to 7
microhenries, and structured with an open center area of from 1
to 10 square centimeters; and

6 b) a capacitor having a capacitance in the range of 10 to 30
7 picofarads.

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1 17. The antenna range extender as recited in claim 12, wherein
2 the antenna range extender is structured for operating with an
3 RF carrier signal in the range of 100 kHz to 15 MHz.

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1 18. The antenna range extender as recited in claim 12, further
2 including a discrete resistor having a resistance in the range
3 of .5 ohms to 50 ohms, with the resistor electrically inserted
4 and coupled in series between one of:

5 a) the first terminal of the capacitor and the first end of
6 the coil; and

7 b) the second terminal of the capacitor and the second end
8 of the coil.

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1 19. The antenna range extender as recited in claim 18, wherein
2 the resistor is provided by one of:

3 a) a discrete resistor; and

4 b) a surface mounted resistor.

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1 20. The antenna range extender as recited in claim 12, wherein
2 the antenna range extender is fixed proximate to the electronic
3 device.

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1 21. The antenna range extender as recited in claim 20, wherein
2 the coil is formed of a conductor fixed upon a substrate and
3 formed of a plurality of substantially concentric turns
4 provided via a spiral pattern upon the substrate.

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1 22. The antenna range extender as recited in claim 21, wherein
2 the coil is formed having an open center area, with the open
3 center area in the range of 1 to 10 square centimeters.

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1 23. The antenna range extender as recited in claim 22, wherein
2 the capacitor is provided by one of:

- 3 a) a discrete non-polarized capacitor;
4 b) a surface mounted non-polarized capacitor; and
5 c) an adjustable trim capacitor.

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1 24. The antenna range extender as recited in claim 12, wherein
2 the antenna range extender is positioned proximate to the RF
3 antenna with an axis establishable between the RF antenna and
4 the electronic device substantially aligned with a center
5 orthogonal axis of the coil of the antenna range extender.

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1 **25.** A magnetically coupled antenna range extender that is
2 placed at a selected distance from an RF antenna, so as to be

3 proximate to, and located substantially upon an axis
4 establishable between the RF antenna and a proximate electronic
5 device in order to increase an operating range at which
6 information may be transmitted between the RF antenna and the
7 electronic device, the antenna range extender comprising:

8 a) a coil having at least one turn, formed substantially
9 upon a common plane and having an open center area, the coil
10 formed of an electrical conductor having a first end and a
11 second end, with each respective open center turn of the
12 conductor positioned proximate to a next turn, with the turns
13 thereby bunched and substantially formed upon the common plane;
14 and

15 b) a capacitor having a first terminal and a second
16 terminal, with the first terminal of the capacitor coupled to
17 the first end of the coil, and the second terminal of the
18 capacitor coupled to the second end of the coil;

19 c) the coil and the capacitor thereby forming a tuned
20 resonate circuit having a resonate frequency substantially
21 equivalent to at least one carrier frequency employed to
22 support an exchange of information between the RF antenna and
23 the electronic device;

24 d) the antenna range extender employable for increasing an
25 operating range when interposed between the RF antenna and the
26 electronic device, and positioned at the selected distance from

27 the RF antenna so as to be magnetically coupled thereto when an
28 RF signal is transmitted by the RF antenna for receiving, via
29 the antenna range extender, by the electronic device.

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1 26. The antenna range extender as recited in claim 25, wherein
2 the antenna range extender is positioned proximate to the RF
3 antenna such that an axis establishable between the RF antenna
4 and the electronic device is aligned with a center orthogonal
5 axis of the coil of the antenna range extender.

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1 27. The antenna range extender as recited in claim 25, further
2 including a resistor having a first terminal and a second
3 terminal, with the resistor inserted in series with the coil
4 and capacitor, thereby forming a series R-L-C tuned resonate
5 circuit.

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1 28. The antenna range extender as recited in claim 25, wherein
2 the electronic device is an RFID device.

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1 29. The antenna range extender as recited in claim 28, wherein
2 the RFID device is a passive RFID tag.

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1 30. The antenna range extender as recited in claim 25, wherein
2 the RF antenna is a portion of a reading head of an RFID

interrogator, and the antenna range extender is mounted proximate to the antenna within a housing of the RFID interrogator.

31. The antenna range extender as recited in claim 25, wherein the coil is formed substantially upon a plane and provided by at least one of:

a) an insulated electrical wire formed into a plurality of looped portions; and

b) a printed circuit coil formed of an electrical conductor that is provided having at least one loop with an open center area, and fixed to a substrate thereof.

32. The antenna range extender as recited in claim 31, wherein:

a) when the coil is formed of the insulated electrical wire, the wire is selected having a wire gauge within the range of 26 to 20 AWG; and

b) when the coil is a printed circuit coil it is formed with a plurality of loops formed substantially concentrically in a spiral pattern;

c) with either coil formed having an inductance in the range of 3 to 7 microhenries.

1 33. The antenna range extender as recited in claim 32, wherein
2 the capacitor is provided by at least one of:

- 3 a) a discrete non-polarized capacitor;
 - 4 b) a surface mounted non-polarized capacitor; and
 - 5 c) an adjustable trim capacitor.
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1 **34.** A magnetically coupled antenna range extender fixed
2 proximate to an electronic device such that magnetic coupling
3 is caused by an RF signal generated and emitted by an antenna
4 of, for example an RFID interrogator, operating proximate to
5 the antenna range extender and electronic device, the antenna
6 range extender comprising:

7 a) a coil formed of at least one loop having an open center
8 area, and formed substantially upon a plane with an electrical
9 conductor, with the coil having a first end and a second end;
10 and

11 b) at least one capacitor having a first terminal and a
12 second terminal;

13 c) wherein the first terminal of the capacitor is
14 electrically coupled to the first end of the coil, and the
15 second terminal of the capacitor is electrically coupled to the
16 second end of the coil;

17 d) the coil and the capacitor thereby forming the tuned
18 resonate circuit having a resonate frequency substantially

equivalent to at least one carrier frequency of an RF signal emitted from the RF antenna, and interposable between the antenna and the electronic device for increasing an operating range therebetween, when a center orthogonal axis of the antenna range extender is substantially aligned with an axis establishable between the RF antenna and the electronic device.

35. The magnetically coupled antenna range extender as recited in claim 34, wherein the electronic device is an RFID device.

36. The magnetically coupled antenna range extender as recited in claim 35, wherein the RFID device is a passive, low cost RFID tag.

37. The magnetically coupled antenna range extender as recited in claim 36, wherein the coil is formed substantially upon a plane with an open center area and provided by a printed circuit coil formed of an electrical conductor that is fixed to a substrate.

38. The magnetically coupled antenna range extender as recited in claim 37, wherein the passive RFID tag and capacitor are each mounted upon the substrate of a printed circuit board.